

# International **IR** Rectifier

## ADVANCED ANALOG HYBRID-HIGH RELIABILITY DC/DC CONVERTERS

### Description

The ATO28XXT Series of DC/DC converters feature high power density and an extended temperature range for use in military and industrial applications. Designed to the nominal input requirements of MIL-STD-704D, these devices have nominal 28VDC inputs with +5V and  $\pm 12V$  or +5V and  $\pm 15V$  triple outputs to satisfy a wide range of requirements. The circuit design incorporates a pulse width modulated push-pull topology operating in the feed-forward mode at a nominal switching frequency of 250KHz. Input to output isolation is achieved through the use of transformers in the forward and feedback circuits.

The advanced feedback design provides fast loop response for superior line and load transient characteristics and offers greater reliability and radiation tolerance than devices incorporating optical feedback circuits.

Three standard temperature grades are offered. Refer to Part Number section. They are provided in a standard plug-in package for PC mounting or in a flanged package for more severe environments.

These converters are manufactured in a facility fully qualified to MIL-STD-1772. All processes used to manufacture these converters have been qualified to enable Advanced Analog to deliver compliant devices. Two screening grades are available to satisfy a wide range of requirements. The CH grade converters are fully compliant to MIL-PRF-38534 for class H. The HB grade converters are processed to full class H screening requirements but do not have class H element evaluation as directed by MIL-PRF-39534. Both grades are fully tested and operate over the full military temperature range without derating of output power. Variations in electrical, mechanical and screening can be accommodated. Extensive computer simulation using complex modeling enables modest design modifications to be accommodated. Contact Advanced Analog with specific requirements.

[www.irf.com](http://www.irf.com)

PD - 94582

### ATO28XXT SERIES

#### 28V Input, Triple Output



### Features

- 16 to 40 VDC Input Range (28VDC Nominal)
- 5V,  $\pm 12V$  or 5V,  $\pm 15V$  Outputs Available
- Indefinite Short Circuit and Overload Protection
- 15 Watts Output Power
- Fast Loop Response for Superior Transient Characteristics
- Operating Temperature Range from  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  Available
- Popular Industry Standard Pin-out
- Resistance Seam Welded Case for Superior Long Term Hermeticity
- Efficiencies up to 81%
- Shutdown from External Signal
- 200,000 Hour MTBF at  $85^{\circ}\text{C}$

## ATO28XXT Series Specifications

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$T_{CASE} = -55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{IN} = +28\text{V} \pm 5\%$  unless otherwise specified

ABSOLUTE MAXIMUM RATINGS							
Input Voltage	-0.5V to 50V						
Power Output	Internally limited, 17.5W typical						
Soldering	300°C for 10 seconds						
Temperature Range <sup>6</sup>	Operating -55°C to +115°C case Storage -65°C to +135°C						

TEST	SYMBOL	Condition $-55^{\circ}\text{C} \leq T_c \leq +85^{\circ}\text{C}$ , $V_{IN} = 28\text{V}_{DC} \pm 5\%$ , $C_L = 0$ unless otherwise specified	ATO2812T		ATO2815T		Units	
			Min	Max	Min	Max		
STATIC CHARACTERISTICS								
OUTPUT Voltage <sup>1</sup>	$V_{OUT}$	$I_{OUT} = 0$ (main) $I_{OUT} = 0$ (dual) <sup>1</sup>	TC = 25°C Over Temp	4.95 4.90	5.05 5.10	4.95 4.90	5.05 5.10	V
Current <sup>1,2,3</sup>	$I_{OUT}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (dual) <sup>1</sup> $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (dual) BW = DC to 2 MHz (main)	TC = 25°C Over Temp	$\pm 11.88$ $\pm 11.76$ 0.0 0.0	$\pm 12.12$ $\pm 12.24$ 2000 $\pm 208$	$\pm 14.85$ $\pm 14.70$ 0.0 0.0	$\pm 15.15$ $\pm 15.30$ 2000 $\pm 167$	V
Ripple Voltage <sup>1,4</sup>	$V_{RIP}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (dual) BW = DC to 2 MHz (dual))		80	40	80	40	mVp-p
Power <sup>1,2,3</sup>	$P_{OUT}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (main) (+dual) (-dual) (total)		10 2.5 2.5 15	10 2.5 2.5 15	10 2.5 2.5 15	W W W W	
REGULATION Line <sup>1,3</sup>	$VR_{LINE}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ $I_{OUT} = 0, 1000, 2000\text{mA}$ (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (dual)	TC = 25°C Over Temp		25		25	mV
Load <sup>1,3</sup>	$VR_{LOAD}$	$I_{IN} = 0, \pm 84, \pm 167\text{mA}$ (dual) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ $I_{OUT} = 0, 1000, 2000\text{mA}$ (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ $I_{OUT} = 0, \pm 84, \pm 167\text{mA}$ (dual)			$\pm 30$ $\pm 60$ 50	$\pm 35$ $\pm 75$ 50	$\pm 75$	mV
INPUT Current	$I_{IN}$	$I_{OUT} = 0$ , Inhibit (pin 8) Tied to input return (pin 10)			15		15	mA
Ripple Current <sup>4</sup>	$I_{RIP}$	$I_{OUT} = 0$ , inhibit (pin 2) = open $I_{OUT} = 2000\text{ mA}$ (main) $I_{OUT} = \pm 167\text{mA}$ (dual) BW = DC to 2MHz			40 50		40 50	mAp-p
EFFICIENCY	$E_{FF}$	$I_{OUT} = 2000\text{mA}$ (main) $I_{OUT} = \pm 167\text{mA}$ (dual)	TC = 25°C	76		76		%
ISOLATION	ISO	Input to output or any pin to case (except pin 7) at 500 VDC,	TC = 25°C	100		100		MΩ
Load Fault Power Dissipation <sup>3</sup>	$P_D$	Overload Short Circuit	TC = 25°C		8 6		8 6	W W
Switching Frequency	$F_s$	$I_{OUT} = 2000\text{mA}$ (main) $I_{OUT} = \pm 167\text{mA}$ (dual)		225	275	225	275	KHz
Inhibit Open Circuit Voltage	$V_{OI}$			9	13	9	13	V

### Notes to Specifications

- Tested at each output.
- Parameter guaranteed by line and load regulation tests.
- At least 20 percent of the total output power should be taken from the (+5V volt) main output.
- Bandwidth guaranteed by design. Tested for 20KHz to 2MHz.
- An overload is that condition with a load in excess of the rated load but less than that necessary to trigger the short circuit protection and is the condition of maximum power dissipation.
- Above 85°C case temperature, derate output power linearly to 0 at 115°C case.

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**Specifications**

**ATO28XXT Series**

$T_{CASE} = -55^{\circ}\text{C}$  to  $+105^{\circ}\text{C}$ ,  $V_{IN} = +28\text{V} \pm 5\%$  unless otherwise specified

ABSOLUTE MAXIMUM RATINGS								
Input Voltage		$-0.5\text{V}$ to $50\text{V}$						
Power Output		Internally limited, $17.5\text{W}$ typical						
Soldering		$300^{\circ}\text{C}$ for 10 seconds						
Temperature Range <sup>6</sup>		Operating $-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ case Storage $-65^{\circ}\text{C}$ to $+135^{\circ}\text{C}$						
TEST	SYMBOL	Condition $-55^{\circ}\text{C} \leq T_c \leq +105^{\circ}\text{C}$ , $V_{IN} = 28\text{ V}_{DC} \pm 5\%$ , $C_L = 0$ unless otherwise specified	ATO2812T/ES		ATO2815T/ES		Units	
			Min	Max	Min	Max		
STATIC CHARACTERISTICS OUTPUT Voltage <sup>1</sup>	$V_{OUT}$	$I_{OUT} = 0$ (main) $I_{OUT} = 0$ (dual) <sup>1</sup>	TC = $25^{\circ}\text{C}$ Over Temp	4.95 4.90 $\pm 11.88$ $\pm 11.76$ 0.0 0.0	5.05 5.10 $\pm 12.12$ $\pm 12.24$ 2000 $\pm 208$ 80	4.95 4.90 $\pm 14.85$ $\pm 14.70$ 0.0 0.0	5.05 5.10 $\pm 15.15$ $\pm 15.30$ 2000 $\pm 167$ 80	V V V mA mA mVp-p
	$I_{OUT}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (dual) <sup>1</sup>	TC = $25^{\circ}\text{C}$ Over Temp	$\pm 11.76$ 0.0 0.0	$\pm 12.24$ 2000 $\pm 208$ 80	$\pm 14.70$ 0.0 0.0	$\pm 15.30$ 2000 $\pm 167$ 80	mA mA mVp-p
	$V_{RIP}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ BW = DC to 2 MHz (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ BW = DC to 2 MHz (dual))			40		40	mVp-p
	$P_{OUT}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (main) (+dual) (-dual) (total)		10 2.5 2.5 15		10 2.5 2.5 15		W W W W
REGULATION Line <sup>1,3</sup>	$VR_{LINE}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ $I_{OUT} = 0, 1000, 2000\text{mA}$ (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (dual)	TC = $25^{\circ}\text{C}$		25		25	mV
	$VR_{LOAD}$	$I_{OUT} = 0, \pm 84, \pm 167\text{mA}$ (dual) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ $I_{OUT} = 0, 1000, 2000\text{mA}$ (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ $I_{OUT} = 0, \pm 84, \pm 167\text{mA}$ (dual)	Over Temp	$\pm 30$ $\pm 60$ 50		$\pm 35$ $\pm 75$ 50	$\pm 35$ $\pm 75$ 50	mV mV mV
INPUT Current	$I_{IN}$	$I_{OUT} = 0$ , Inhibit (pin 8) Tied to input return (pin 10)			15		15	mA
	$I_{RIP}$	$I_{OUT} = 0$ , inhibit (pin 2) = open $I_{OUT} = 2000\text{ mA}$ (main) $I_{OUT} = \pm 167\text{mA}$ (dual) BW = DC to 2MHz			40 50		40 50	mA mA mAp-p
EFFICIENCY	$E_{FF}$	$I_{OUT} = 2000\text{mA}$ (main) $I_{OUT} = \pm 167\text{mA}$ (dual) TC = $\pm 25^{\circ}\text{C}$	TC = $25^{\circ}\text{C}$	76		76		%
ISOLATION	ISO	Input to output or any pin to case (except pin 7) at $500\text{ VDC}$ , TC = $+25^{\circ}\text{C}$	TC = $25^{\circ}\text{C}$	100		100		MΩ
Load Fault Power Dissipation <sup>3</sup>	$P_D$	Overload, TC = $+25^{\circ}\text{C}^5$ Short Circuit, TC = $+25^{\circ}\text{C}$	TC = $25^{\circ}\text{C}$		8 6		8 6	W W
Switching Frequency	$F_s$	$I_{OUT} = 2000\text{mA}$ (main) $I_{OUT} = \pm 167\text{mA}$ (dual)		225	275	225	275	KHz
Inhibit Open Circuit Voltage	$V_{OI}$			9	13	9	13	V

Notes to Specifications

- Tested at each output.
- Parameter guaranteed by line and load regulation tests.
- At least 20 percent of the total output power should be taken from the (+5V volt) main output.
- Bandwidth guaranteed by design. Tested for 20KHz to 2MHz.
- An overload is that condition with a load in excess of the rated load but less than that necessary to trigger the short circuit protection and is the condition of maximum power dissipation.
- Above  $105^{\circ}\text{C}$  case temperature, derate output power linearly to 0 at  $125^{\circ}\text{C}$  case

## ATO28XXT Series

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### Specifications

$T_{CASE} = -55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ,  $V_{IN} = +28\text{V} \pm 5\%$  unless otherwise specified

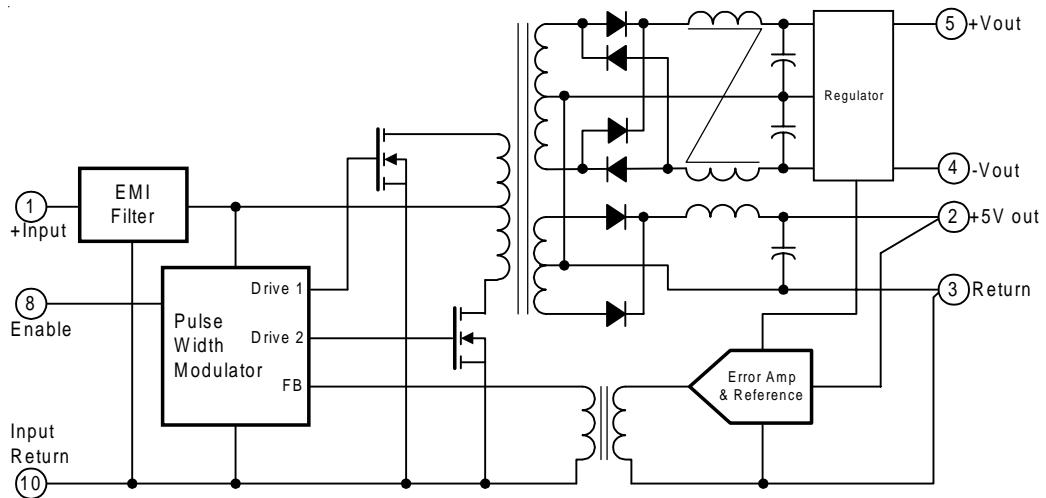
ABSOLUTE MAXIMUM RATINGS							
Input Voltage		$-0.5\text{V}$ to $50\text{V}$					
Power Output		Internally limited, $17.5\text{W}$ typical					
Soldering		$300^{\circ}\text{C}$ for 10 seconds					
Temperature Range <sup>6</sup>		Operating $-55^{\circ}\text{C}$ to $+135^{\circ}\text{C}$ case Storage $-65^{\circ}\text{C}$ to $+135^{\circ}\text{C}$					

TEST	SYMBOL	Condition $-55^{\circ}\text{C} \leq T_C \leq +125^{\circ}\text{C}$ , $V_{IN} = 28\text{V}_{DC} \pm 5\%$ , $C_L = 0$ unless otherwise specified	ATO2812T/HB		ATO2815T/HB		Units
			Min	Max	Min	Max	
STATIC CHARACTERISTICS OUTPUT							
Voltage <sup>1</sup>	$V_{OUT}$	$I_{OUT} = 0$ (main) $I_{OUT} = 0$ (dual) <sup>1</sup>	TC = $25^{\circ}\text{C}$ Over Temp	4.95 4.90 $\pm 11.88$ $\pm 11.76$	5.05 5.10 $\pm 12.12$ $\pm 12.24$	4.95 4.90 $\pm 14.85$ $\pm 14.70$	5.05 5.10 $\pm 15.15$ $\pm 15.30$
Current <sup>1,2,3</sup>	$I_{OUT}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (dual) <sup>1</sup>	TC = $25^{\circ}\text{C}$ Over Temp	0.0 0.0	2000 $\pm 208$ 80	0.0 0.0	2000 $\pm 167$ 80
Ripple Voltage <sup>1,4</sup>	$V_{RIP}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ BW = DC to 2 MHz (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ BW = DC to 2 MHz (dual))			40		40
Power <sup>1,2,3</sup>	$P_{OUT}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (main) (+dual) (-dual) (total)		10 2.5 2.5 15		10 2.5 2.5 15	W W W W
REGULATION							
Line <sup>1,3</sup>	$VR_{LINE}$	$V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ $I_{OUT} = 0, 1000, 2000\text{mA}$ (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ (dual)	TC = $25^{\circ}\text{C}$ Over Temp		25		25
Load <sup>1,3</sup>	$VR_{LOAD}$	$I_{OUT} = 0, \pm 84, \pm 167\text{mA}$ (dual) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ $I_{OUT} = 0, 1000, 2000\text{mA}$ (main) $V_{IN} = 16, 28, \text{ and } 40\text{ VDC}$ $I_{OUT} = 0, \pm 84, \pm 167\text{mA}$ (dual)			$\pm 30$ $\pm 60$ 50	$\pm 35$ $\pm 75$ 50	mV mV mV
INPUT Current	$I_{IN}$	$I_{OUT} = 0$ , Inhibit (pin 8) Tied to input return (pin 10)			15		15
Ripple Current <sup>4</sup>	$I_{RIP}$	$I_{OUT} = 0$ , inhibit (pin 2) = open $I_{OUT} = 2000\text{ mA}$ (main) $I_{OUT} = \pm 167\text{mA}$ (dual) BW = DC to 2MHz			40 50		40 50
EFFICIENCY	$E_{FF}$	$I_{OUT} = 2000\text{mA}$ (main) $I_{OUT} = \pm 167\text{mA}$ (dual) TC = $\pm 25^{\circ}\text{C}$	TC = $25^{\circ}\text{C}$	76		76	%
ISOLATION	ISO	Input to output or any pin to case (except pin 7) at $500\text{ VDC}$ , TC = $+25^{\circ}\text{C}$	TC = $25^{\circ}\text{C}$	100		100	MΩ
Load Fault Power Dissipation <sup>3</sup>	$P_D$	Overload, TC = $+25^{\circ}\text{C}^5$ Short Circuit, TC = $+25^{\circ}\text{C}$	TC = $25^{\circ}\text{C}$		8 6		8 6
Switching Frequency	$F_s$	$I_{OUT} = 2000\text{mA}$ (main) $I_{OUT} = \pm 167\text{mA}$ (dual)		225	275	225	275
Inhibit Open Circuit Voltage	$V_{OI}$			9	13	9	13
							V

### Notes to Specifications

- Tested at each output.
- Parameter guaranteed by line and load regulation tests.
- At least 20 percent of the total output power should be taken from the (+5V volt) main output.
- Bandwidth guaranteed by design. Tested for 20KHz to 2MHz.
- An overload is that condition with a load in excess of the rated load but less than that necessary to trigger the short circuit protection and is the condition of maximum power dissipation.
- Above  $125^{\circ}\text{C}$  case temperature, derate output power linearly to 0 at  $135^{\circ}\text{C}$  case

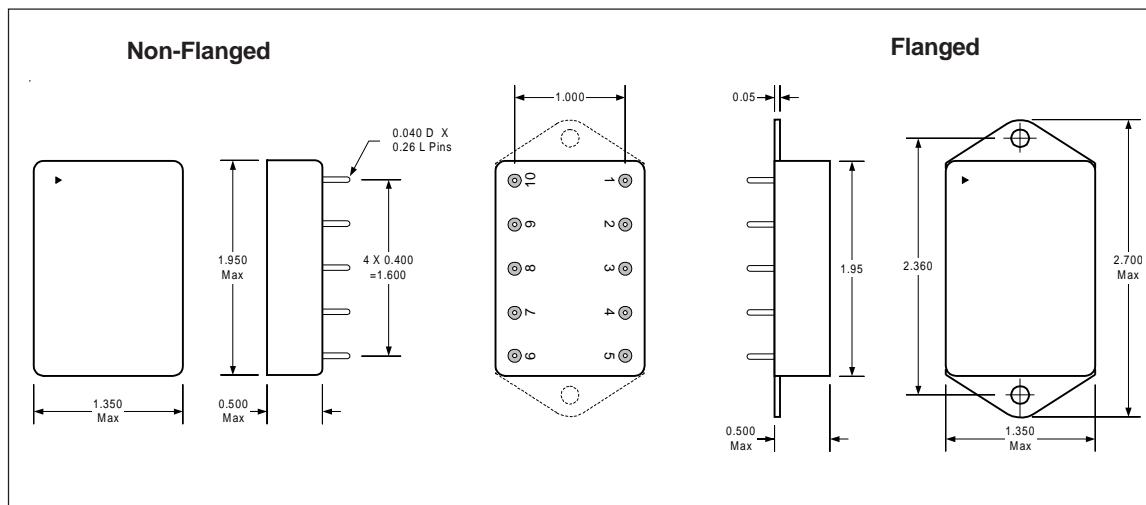
**ATO28XXT Block Diagram**



## ATO28XXT Series

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### ATO28XXT Case Outline



### Pin Designation

Pin No.	Designation
1	+ Input
2	+ 5V Output
3	Output Return
4	-Dual Output
5	+ Dual Output
6	N/C
7	Case Ground
8	Enable Input
9	N/C
10	Input Return

### Part Numbering

ATO 28 15 T / CH

Model

Input Voltage  
28 = 28V

Output Voltages  
15 = 5V, ± 15V  
12 = 5V, ± 12V

Screening Level  
—, ES, HB, CH

Outputs  
T = Triple

**Available Screening Levels and Process Variations for ATO28XXT Series**

Requirement	MIL-STD-883 Method	No Suffix	ES Suffix	HB Suffix	CH Suffix
Temperature Range		-55°C to +85°C	-55°C to +125°C	-55°C to +125°C	-55°C to +125°C
Element Evaluation					MIL-PRF-38534
Internal Visual	2017	*	Yes	Yes	Yes
Temperature Cycle	1010, Cond C		Cond A	Yes	Yes
Constant Acceleration	2001, Cond A		500g	5,000g	5,000g
Burn-in	1015	48 hrs @ 85°C	48hrs @ 105°C	160hrs @ 125°C	160hrs @ 125°C
Final Electrical (Group A)	MIL-PRF-38534 & Specification	25°C	25°C	-55, +25, +125°C	-55, +25, +125°C
Seal, Fine & Gross	1014		Yes	Yes	Yes
External Visual	2009	*	Yes	Yes	Yes

\* Per Commercial Standards

**Available Standard Military Drawing (SMD) Cross Reference**

Standardized Military Drawing Pin	Vendor CAGE Code	Vendor Similar Pin
5962-9095401HXX	52467	ATO2815T/CH
5962-9095401HZX	52467	ATO2815TF/CH
5962-9160201HXX	52467	ATO2812T/CH
5962-9160201HZX	52467	ATO2812TF/CH

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**ADVANCED ANALOG:** 2270 Martin Av., Santa Clara, California 95050, Tel: (408) 727-0500

Visit us at [www.irf.com](http://www.irf.com) for sales contact information.

*Data and specifications subject to change without notice. 11/02*